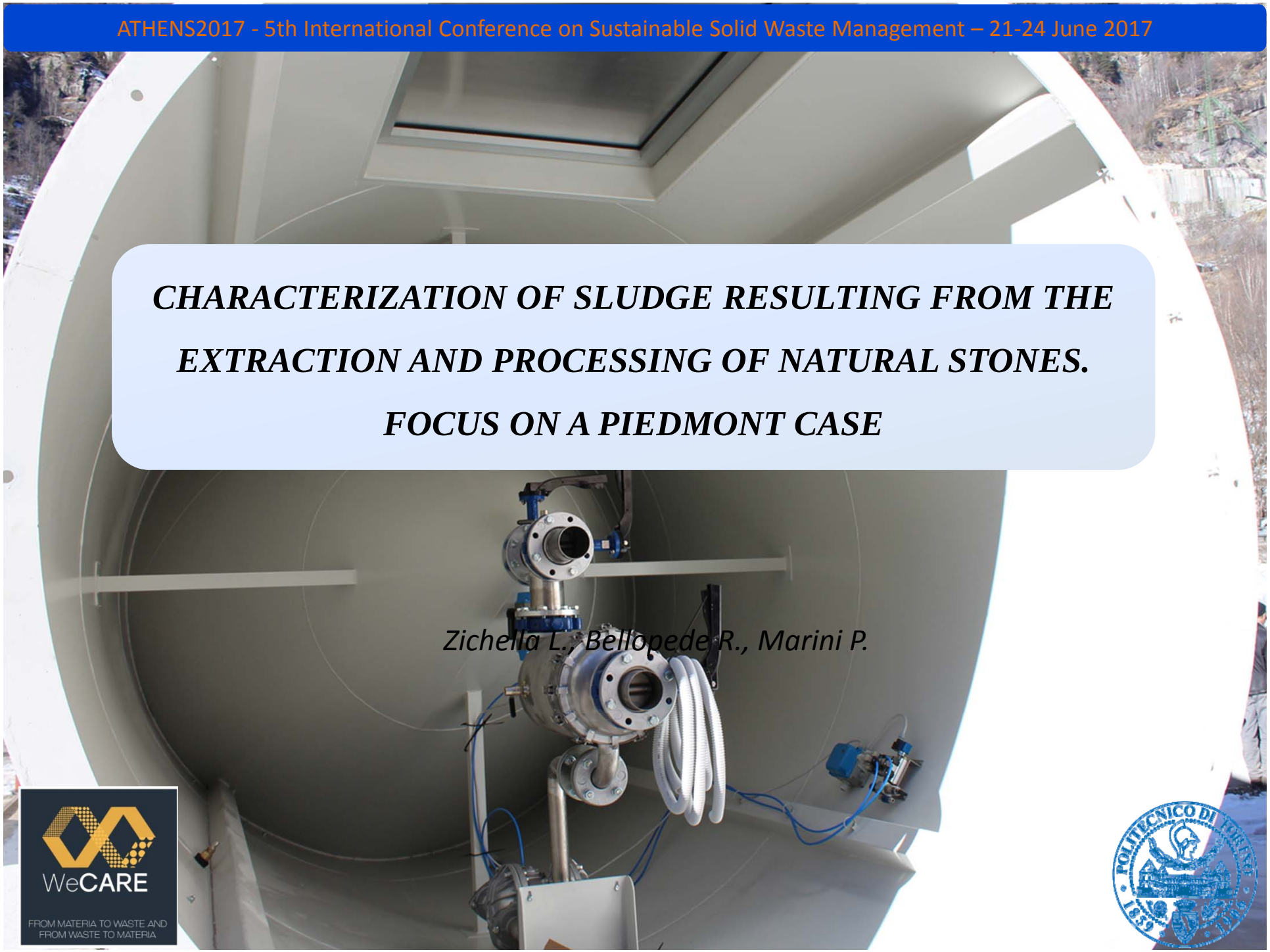
Characterization of sludge resulting from the extraction and processing of natural stones. focus on a Piedmont case



CHARACTERIZATION OF SLUDGE RESULTING FROM THE EXTRACTION AND PROCESSING OF NATURAL STONES. FOCUS ON A PIEDMONT CASE

Zichella L., Bellopede R., Marini P.

WeCARE
FROM MATERIA TO WASTE AND FROM WASTE TO MATERIA

POLITECNICO DI TORINO 1859

EUROPEAN LEGISLATION ON ROCKS SAWING WASTE, EUROPEAN PILLARS AND DEFINITIONS

European Directive 2006/21/EC: Measures for the management of waste arising from mining activities.
These measures **should** be based on concept of ***'best available technique***' (Directive 2010/75 /UE) at moment not yet defined.
Pillars: Draw up appropriate waste management plans for the prevention or minimization, treatment, recovery and disposal of extractive waste. They must be structured in such a way as to ensure appropriate planning of waste management options in order to minimize the waste generation and its harmfulness, and encouraging waste recovery. Moreover, waste should be characterized with respect to its composition to ensure human and environmental health.

European Commission strategies for Raw Material:

- ✓ laying the foundations for a European policy of strategic raw materials production and consequently extraction mining option
- ✓ creating a European Innovation Partnership and the dissemination of new technologies
- ✓ reduction of waste generated and recovery of critical raw material (CRM)
- ✓ decreasing in potential soil contamination
- ✓ prevention of transport of dangerous waste
- ✓ reduction of energy consumption
- ✓ zero impact on air pollution
- ✓ cost reduction

BY-PRODUCT:
substance or object, resulting from a production process, the primary aim of which is not the production of that item. (D.Lgs. 205/2010 implementation of Directive 2008/98/EC).
Requirements for the subject or substance:

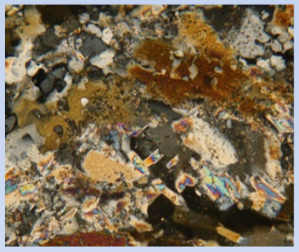
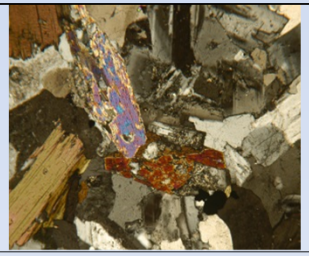
- **the certainty of its further use,**
- It can be used directly without any additional treatment different from **normal industrial practice**
- It is integrated in a production process and it satisfies the requirements for human health and environment protection

PURPOSE OF RESEARCH:

The aim of the research is to properly identify the *"best available techniques"* for extraction and processing of stones in order to obtain less waste and less pollution, in accordance with the European directive.

For this purpose, two Piedmont silicatic stones and their sawing sludges have been characterized.

MATERIALS:

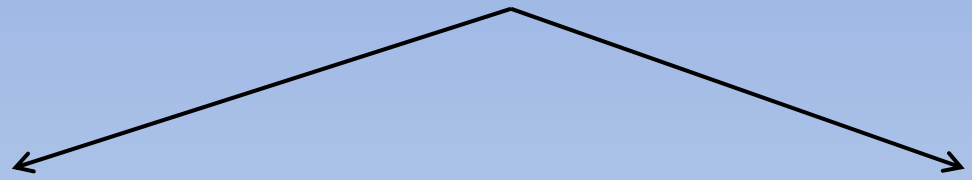
Trade name of the stone	Macrophoto	Microphoto	Mineralogical composition	Description
Perosa Stone			Quartz 45% Plagioclase 20% Mica 15% Epidote – Zoisite 15% Accessory minerals: chlorite, biotite, zircon 5%	Dioritic gneiss - Metamorphic rock with clear and dark foliation due to lamellar phyllosilicate. Medium-fine grained. Presence of quartz and chlorite veins.
Traversella Diorite			Quartz 15% Plagioclase 60% Biotite, Chlorite Opaque and accessory minerals 15% Pyroxene 10%	Dioritic magmatic rock, fine grained and light grey coloured. Isotropic fabric.

THE PLANTS

PEROSA STONE

DIORITE STONE

ANALYSIS CARRIED OUT:



STONES CHARACTERIZATION

- Apparent bulk density
- Absorption coefficient
- Compressive strenght
- Flexural strenght
- Impact resistance
- Knoop microhardness
- UPV – Ultrasound pulse velocity

SLUDGE CHARACTERIZATION

- Particle size distribution
- chemical analysis
- leaching test
- wet magnetic separation
- SEM EDS analysis

All the stones characterization analysis and particle size distribution were performed in accordance with the EN standards, chemical and leaching test on the sludge have been carried out in accordance to European directives.

STONES CHARACTERIZATION

TESTS	measurement unit	DIORITE TRAVERSELLA	PEROSA STONE
Apparent bulk density (EN 1936:2006)	kg/m^3	2814	2756
Absorption coefficient (EN13755:2007)	%	0.36	0.32
Compressive strength (EN1926:2006)	MPa	**215**	**122**
Flexural strength (EN 12372:2006)	MPa	**21.1**	**29.0**
Impact resistance (UNI EN 14158:2005)	cm	71.3	85.0

Trade name of the stone	UPV // m/s	UPV ⊥ m/s	Knoop HK25 (EN 14205:2003)
Traversella Diorite	2631	2576	3295
Perosa Stone	2366	2918	2482

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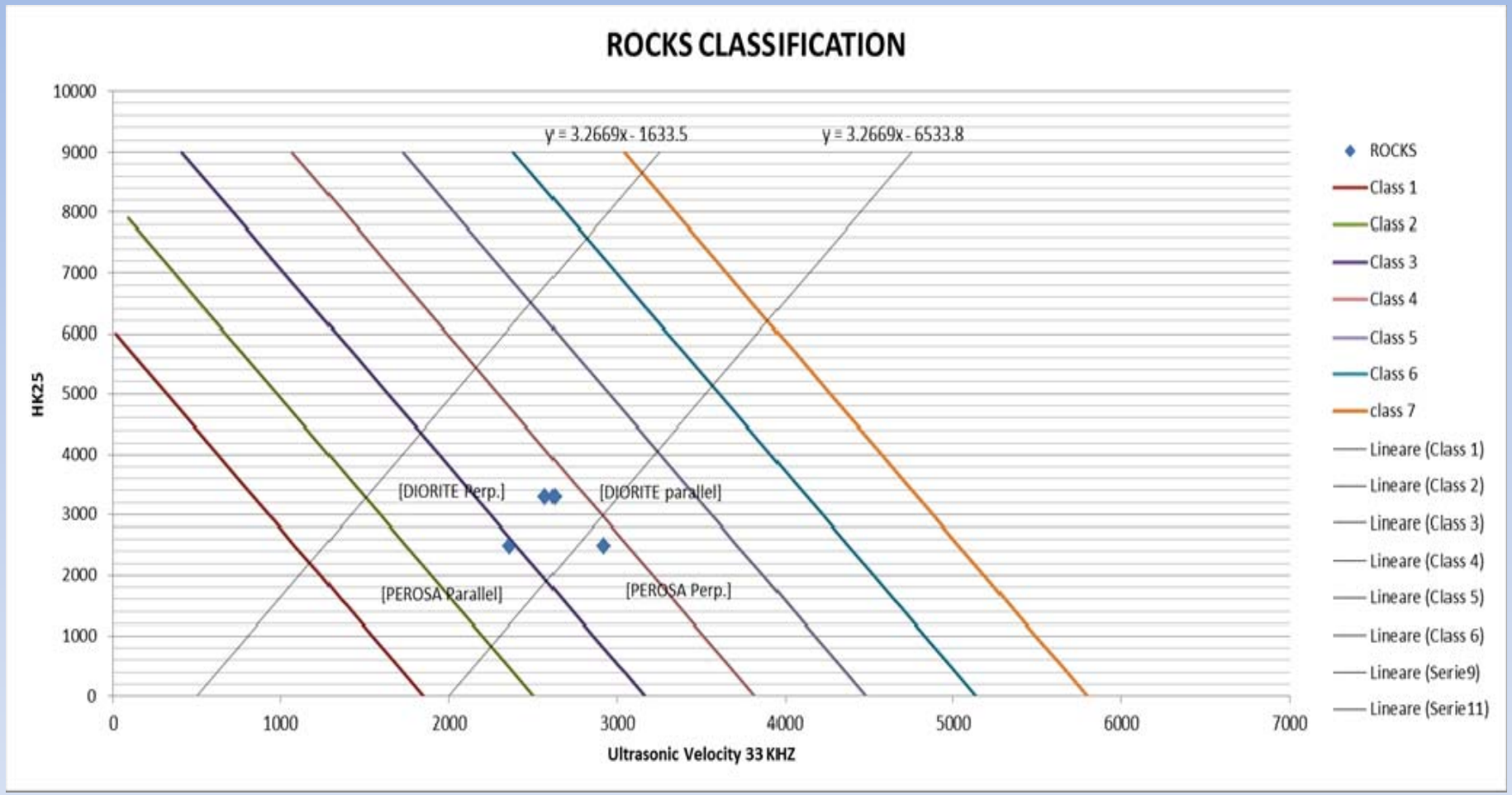
STONES CHARACTERIZATION



Based on the research carried out with the European EASE R3 project, reference: ”Diamond-wire cutting: a methodology to evaluate stone workability” Zichella et. al., 2017.

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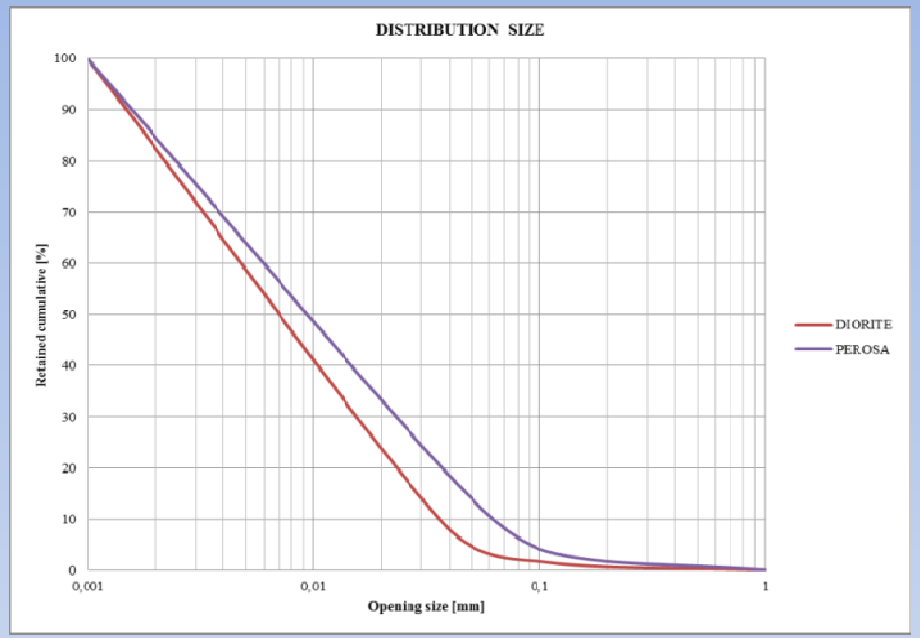
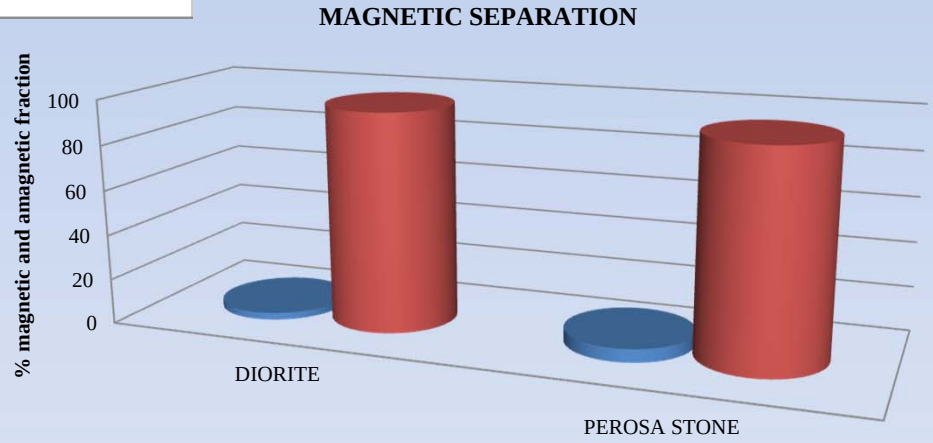
SLUDGE CHARACTERIZATION



The *particle size distribution* was performed in wet conditions, using two sieves (0.038mm, 0.106mm), in order to obtain three classes. This analysis is necessary to understand which particle size class presents the highest concentration of metals and to choose the best separation method.

Magnetic wet separation was performed to separate the metallic fraction with magnetic characteristics from the mineral fraction of the sludge. This type of separation allows those metals to be separated and identified. Their recovery and re-use is an important aspect for a circular economy (EU pillars).



	DIORITE	PEROSA STONE
% Magnetic fraction	3,1	5,9
% Amagnetic fraction	96,9	94,1

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SLUDGE CHARACTERIZATION

The *chemical analysis* and leaching test were conducted in accordance with Italian D.L. 205/2010, which provides two reference tables that show the concentration limits of metals in sludge.

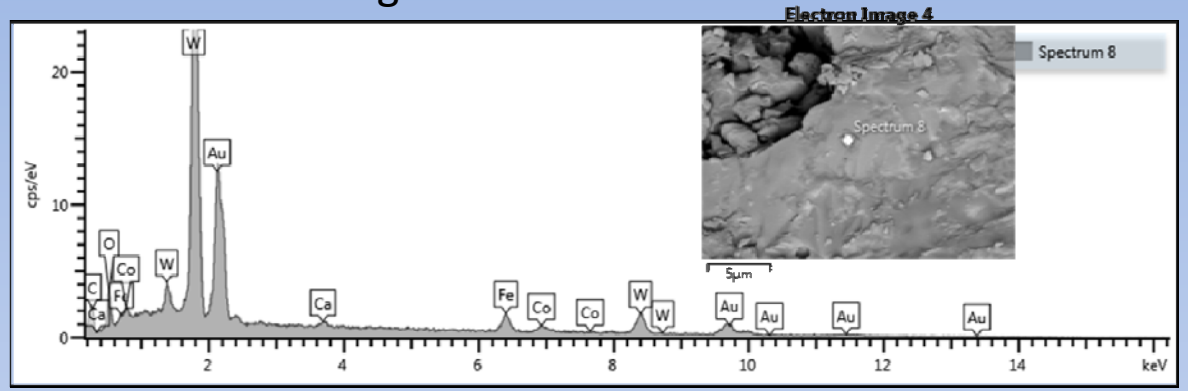
Leaching tests, for the characterization of the eluate, were carried out in accordance with Annex 3 of D.M. 186/2006

TRADE NAME OF THE STONE	Cr	Fe	Co	Zn	Ni	Cu	Mo	Sn	W
	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
DIORITE TRAVERSELLA	18,21	2,75	26,15	24,82	/	41,89	13,15	8,67	33,23
PEROSA STONE	37,75	2,41	26,74	25,04	0,32	38,66	14,36	7,21	24,42

TRADE NAME OF THE STONE	Al (ppb)	V (ppb)	Cr (ppb)	Mn (ppb)	Fe (ppb)	Co (ppb)	Ni (ppb)	Cu (ppb)	Zn (ppb)	Ga (ppb)	As (ppb)	Rb (ppb)	Sr (ppb)	Cd (ppb)	Ba (ppb)	Pb (ppb)
DIORITE TRAVERSELLA	89.27	3.12	0.12	17.44	3.28	1.41	0.00	22.47	0.44	2.90	8.28	5.23	102.7	0.00	12.87	0.00
PEROSA STONE	122.6	2.51	0.00	29.40	9.33	1.01	0.00	17.96	0.73	1.05	15.47	8.82	46.58	0.00	4.41	0.00

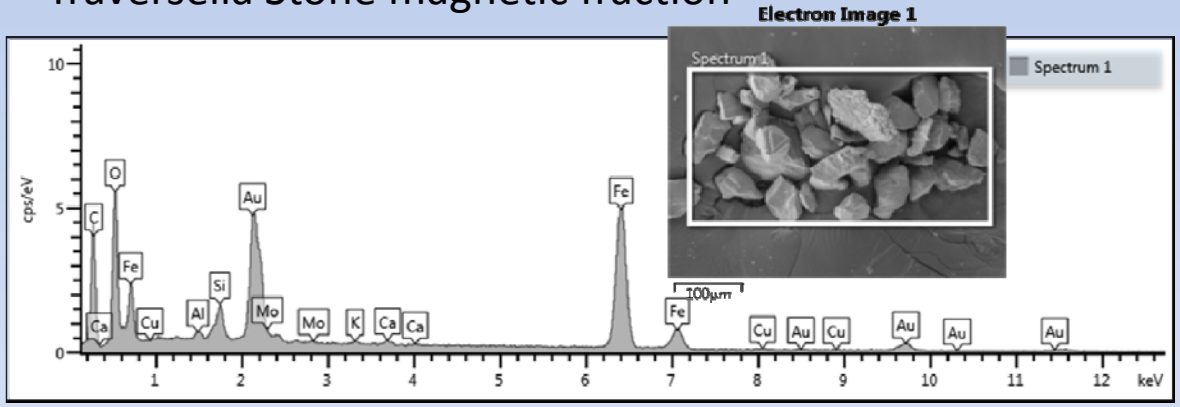
MAGNETIC FRACTION

Perosa Stone magnetic fraction



Element	Wt%	Wt% Sigma
C	14.05	0.74
O	11.19	0.45
Ca	0.68	0.11
Fe	6.32	0.28
Co	2.74	0.30
W	65.02	0.73
Total:	100.00	

Traversella Stone magnetic fraction



Element	Wt%	Wt% Sigma
C	39.66	0.53
O	22.60	0.31
Al	0.28	0.03
Si	1.00	0.04
K	0.15	0.03
Ca	0.25	0.04
Fe	34.97	0.36
Cu	0.00	0.00
Mo	1.07	0.19
Total:	100.00	

OBSERVATION :

- ✓ Mechanical Characteristics of the stones:

Workability	Traversella Diorite	CLASS 3
	Perosa Stone	CLASS 2 (// foliation planes)
		CLASS 3 (⊥ foliation planes)
Compressive strenght	Traversella Diorite	215 MPa
	Perosa Stone	122 MPa
Flexural strenght	Traversella Diorite	21,1 MPa
	Perosa Stone	29 MPa

- ✓ Sludge analysis:

Wet magnetic separation:	Traversella Stone	3,1 % Magnetic fraction
	Perosa Stone	5,9 % Magnetic fraction

- ✓ Plants cutting methods:

Traversella Stone	Diamond Wire	Ø = 7mm ÷ 10 mm	Cutting width=11÷12mm
Perosa Stone	Diamond Blade	thikness = 10 mm	Cutting width=13mm

- ✓ Interaction between *mechanical characteristics of a stone* and the *wear of the tools*.

CONCLUSIONS

Directive 2006/21/EC defines **<u>treatment</u>**: "*A process or combination of mechanical, physical, biological, thermal, or chemical processes on mineral resources, including the exploitation of quarries, the extraction of minerals, the modification of the mineral size, classification, separation and leaching, and the reprocessing of previously discarded material. However, melting and thermal processes (which differ according to the calcination of a limestone) and metallurgical operations are excluded.*"

→ WET MAGNETIC SEPARATION : Simple and inexpensive separation method

↓

In order to obtain two byproduct:

↙ Magnetic fraction: metals

↘ Amagnetic fraction: minerals

UNIDIRECTIONAL SYSTEM → CIRCULAR SYSTEM

Future development: possible reuse of the two fraction

Thanks for your attention !!!

DIATI - Department of Environment, Land and Infrastructure Engineering
Politecnico di Torino, Italy

WEB SITE.: http://areeweb.polito.it/rawmaterials/index_en.html